The Coronation Hall in the historic town hall of Aachen, Germany

Corona:
Audio AR for historic sites

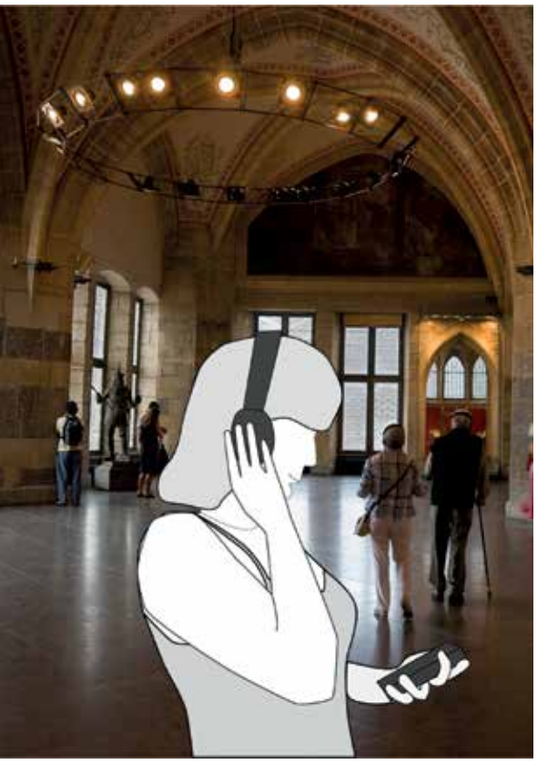
by Florian Heller

Many historic sites, as important they may have been, often lack visual cues to events that took place there. Sites become ruins or are changed intentionally through structural modification. The city hall of Aachen, Germany is an example of such a site. Built in the 9th century, it was the seat of Charlemagne's and several other emperors' governments, and it is still in use as city hall today. Among the most important ceremonies that took place in its Coronation Hall were the coronation feasts of the 15th and 16th century. However, the only visual remainder is a set of coats of arms engraved in the pavement. The Route Charlemagne[1] (www.route-charlemagne.eu) project was initiated to make several historic buildings in Aachen accessible to the public. The main focus was on the city hall, since it was only possible to be visited as part of a guided tour. To allow a self-paced exploration, we created a series of interactive exhibits and

the Aixplorer audio guide, which automatically detects the room you are in. For the Coronation Hall, we wanted to create a landmark exhibit that reminds visitors of the important ceremonies that happened there. As the hall is regularly used for public activities and is under monumental protection, fixed installations were not an option. Since the visual impression of the room had to stay untouched, we decided to create an audio-only exhibit.

The Corona audio space

Corona is an audio augmented reality experience that overlays the physical space with a virtual audio space, generating an impression of being right in the middle of a coronation feast. You would probably imagine such a banquet as a lavish celebration, but that was only true for the populace gorging on meat and drinking from the fountain of wine. The nobility had to follow protocol. The ceremony of the coronation of Charles V from the 16th century is very well documented, which gave us the opportunity to bring some of the attendees back to life.



Corona use concept

In the Corona audio space, virtual characters are placed at their historically handed down positions. In groups of two they discuss different aspects of the ceremony. For example, the newly crowned King discusses matters of the Black Death with the Archbishop, servants describe the order of the dishes, and two persons standing by the window observe the festivities on the market place.

The technology behind the scenes

To create the illusion that the audio sources are located at fixed positions in the physical space, we need information about the user's position and head orientation. The Coronation Hall is 45 by 20 meters large with four stone pillars in the middle of the room, which makes location tracking difficult if it is supposed to be invisible. Furthermore, optical tracking using video cameras has to meet strict privacy regulations. We opted for a Ubisense wireless radio location tracking system that performs with an accuracy of 10-50 cm and delivers updates 4 times per second. The orientation is measured by a digital compass chip, with an update rate of 10 Hz, mounted to the headphones. This information is then fed into the OpenAL spatial audio rendering engine available on iOS. Since the results of this engine do not provide a good separation of sources that are directly in front or behind you (a common problem with spatial audio rendering called *front-back confusion)*, we added a low-pass filter to the signal coming from a source behind the listener. To avoid an auditory overload resulting in poor localization, we pause sources that are more than 11 meters away.

The overall result of the rendering is not perfectly realistic, but plausible and results in an entertaining experience. In fact, a realistic simulation of the room's acoustics would lead to a poor understanding of the dialogs as the hall's natural reverb makes it impossible to communicate over a distance larger than eight meters.

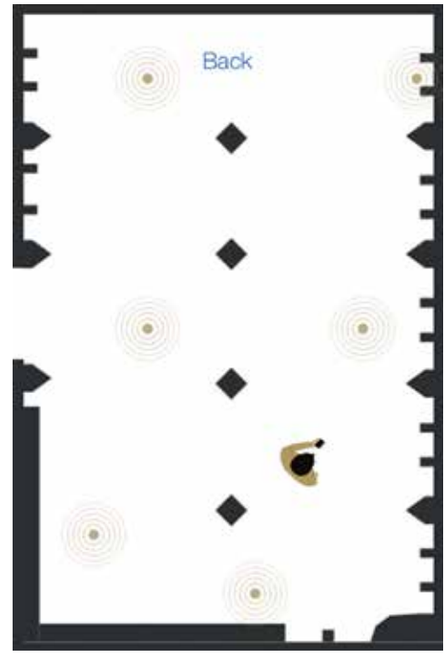
Individual audio spaces

As with traditional audio guides, the audio space is individual to the listener. Usually, this is used to provide the content in different languages or for different audiences, e.g., a simplified version for children. With our continuous audio space, however, we can create a more playful approach. Moving sound sources could lure people to areas that they have not yet explored or create an audio scavenger hunt. The continuous audio space also has the advantage that features which need manual intervention or additional implementation effort with traditional audio guides, such as synchronized playback, can easily be achieved. Depending on the path that a user takes, the different sources start and stop playing at different points in time. Thus, to experience the audio space as a group, you just have to walk side by side, without having to make sure that you press play at the same time.

A visitor explained his impression as follows: *"Corona is an emotional experience, like a film. This is much more interesting and thus memorable than a normal audio guide"*. The act of discovering hidden information was clearly favored over learning plain facts as with traditional audio guides.

Challenging the authors

The challenge in writing the dialogs of the audio space was mainly the fact that we did not know when the visitor would actively be listening to the source. In contrast to classic audio guides, several sources might be playing but the visitor is only actively listening to one of these. This means that key information has to be presented repeatedly, but using short audio fragments bears the risk that the visitor notices the loop. In our content, key information is repeated several times in different words, allowing a late drop-in.



Spatial layout of auditory sources in the Coronation Hall

Simplifying the implementation

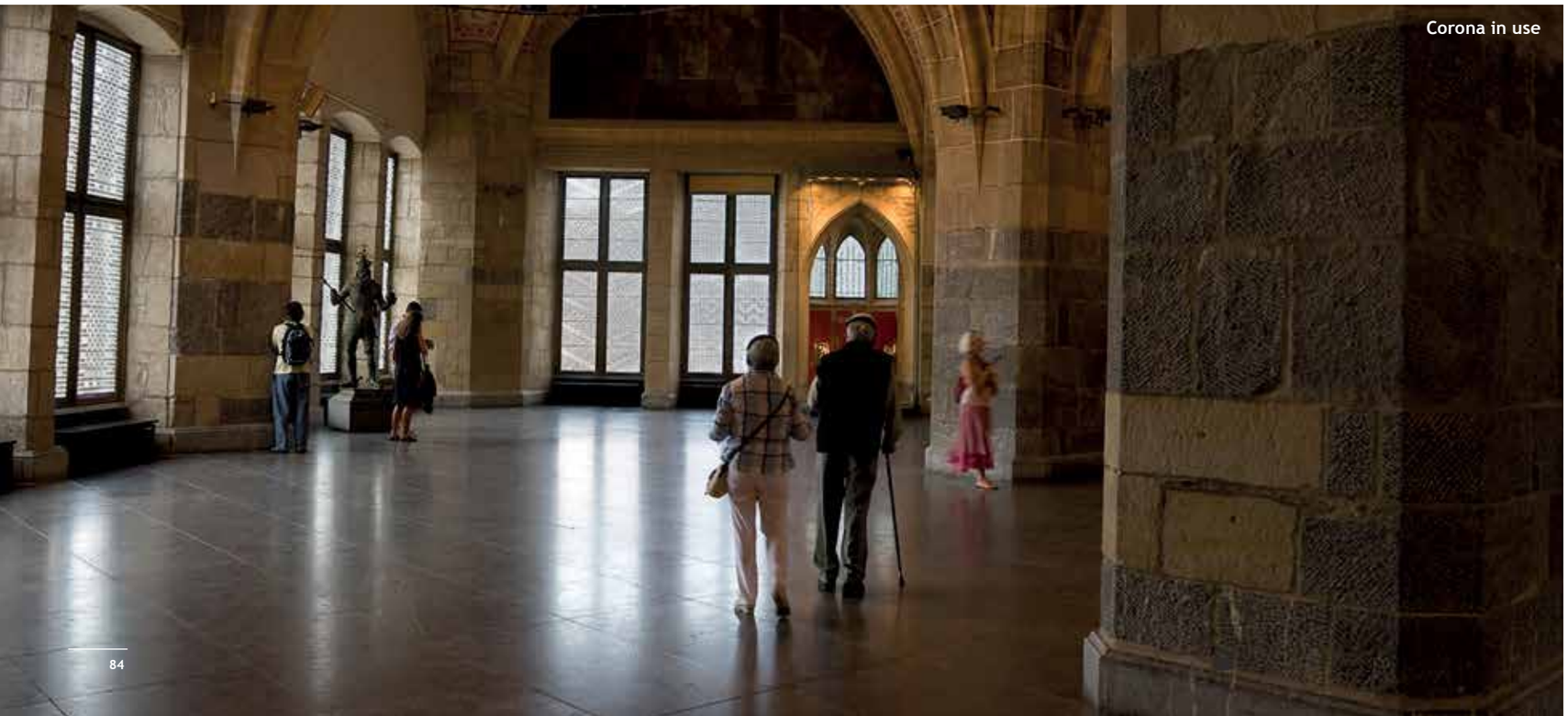
The human brain is quite good at making sense out of sensory information that does not fit exactly. For example, if a virtual sound should emerge from a specific physical artifact, but the perceived location of the virtual sound source and the location of the artifact slightly differ, the virtual source seems to snap to that physical location (the so called ventriloquist effect [1]). A visitor experienced a similar effect when the network connection used to transmit the location data broke down. Since the rendering engine could only use the head orienta-

tion, the distance to the sources was not updated anymore. She interpreted this a bit different and told us: *"That was amazing! After some time, the voices started walking with me!"*

Based on these effects, and the observation that many users of our system do not turn their head to orient themselves in the audio space, but instead turn their entire body, we investigated whether the implementation of a system like Corona could be simplified. The hardware requirements for this exhibit make it a complex installation; every headphone needs to be equipped with a compass, which has to be interfaced with the smartphone. Similarly, the location information has to be communicated to the audio guides as well. Since current smartphones are equipped with location and orientation sensors, the required hardware is basically already available. Using these built-in sensors does not allow the same degree of realism, since they only measure the orientation of the device - not the head, but our current experiments [2] indicate that using device orientation does not dramatically affect the perceived presence in the virtual environment. The localization accuracy does not necessarily need to be as high as in our implementation. A series of outdoor installations, a sound garden in a municipal park [3] for example, have used GPS to get location information and this was not perceived as a problem.

Outlook

Audio augmented reality applications are engaging experiences that go beyond the plain presentation of historic facts. In the context of a museum it can be used to create an atmosphere the user dives into and that stimulates the visitor's fantasy. Current smartphones provide enough processing power to handle the spatial audio rendering and if realism is not the top priority, their built-in sensors provide all required information. So there aren't any excuses not to have an audio AR app for your museum. ■



Corona in use

Acknowledgements

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References

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Florian Heller is a PhD Student in the Media Computing Group at RWTH Aachen University in Germany. From 2009 to 2012 he was a fellow of the B-IT Research School. He worked on the implementation of Corona as his Diploma Thesis and continued his research in the field of physical interaction with audio. The physical component can either be movement like in Corona, or interaction with tangible interfaces such as an augmented DJ turntable or with wearable interfaces.

http://hci.rwth-aachen.de/heller
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